Tracking the prey rather than the predator with GNSS

The paper presents an indirect GNSS-based method for the tracking of drop bears to effectively map the animal population, study animal behaviour and enhance conservation efforts.

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Global Navigation Satellite System (GNSS) technology has revolutionised the way 3-dimensional positions are determined on and above the Earth's surface. GNSS-based positioning has become a vital tool for a wide range of applications in areas such as surveying, mapping, asset management, precision agriculture, engineering and construction. A lesser known application that has benefited immensely from the introduction of GNSS technology is animal tracking.

Australia is home to many unique animals. For about 50 years, the tagging and tracking of animals has been invaluable in the quest to better understand animal behaviour and ecology (the study of the relationships that living organisms have with respect to each other and their natural environment). Monitoring animal populations is also necessary for conservation purposes, particularly in an era of human expansion into traditional animal habitats. Several species, such as the Tasmanian devil, are currently declining. Others, such as the drop bear, are rarely seen. Too little is known about many indigenous species whose status may be threatened.

Over the last two decades, the use of GNSS technology has been responsible for significant advances in this field (Tomkiewicz et al., 2010). GNSS provides the ability to obtain accurate, regular and frequent estimates of the changing distributions of many rare animal species. However, employing conventional GNSS-based animal tracking methods to study drop bears and other tree-dwelling animals is extremely difficult due to their habitat. The dense tree canopy regularly causes extended periods of complete GNSS signal loss, and sensors are often damaged during attacks on prey.

This paper outlines an alternative, indirect GNSS-based approach for tracking drop bears. Rather than attaching sensors to the animals themselves, the prey is tracked in order to map the population. A case study demonstrates that this method can effectively estimate the number and spatial distribution of drop bears in the area. It also provides valuable insights into the animal's hunting behaviour.

GNSS-based animal tracking

Initially animal tracking relied on VHF (very high frequency) radio technology. The main disadvantages of this method are the requirement of receivers being close enough to the animals to triangulate animal positions and the low temporal resolution of position fixes. The arrival of GNSS technology has revolutionised animal tracking because it allows the continuous recording of accurate positions. Now it is possible to obtain animal trajectories, rather than having to rely on occasional snapshots of the animal's whereabouts. While the first attempts of employing GNSS for animal tracking appeared to be rather clumsy (Figure 1), the technology was quickly embraced and optimised for this application through the development of animal collars.

Figure 1: First attempts of GNSS-based animal tracking.

At first, only large animals such as elephants, camels and bears were able to

Figure 2: Cattle wearing collars for automated animal control (Swain et al., 2009).

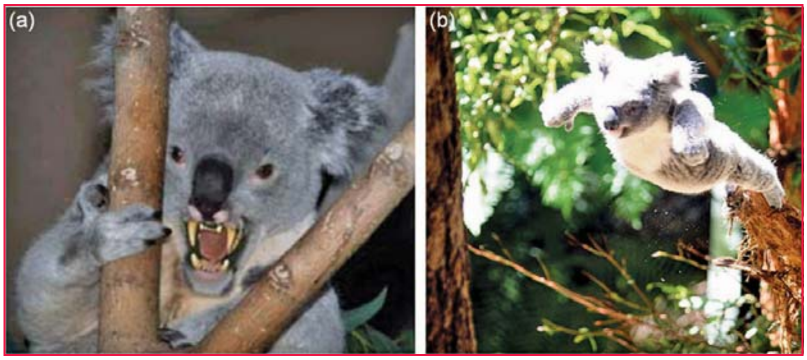


Figure 3: Drop bear (a) in its habitat and (b) attacking prey.

be tracked due to the considerable sensor size and the reliance on rather large, heavy battery packs (e.g. Schwartz and Arthur, 1999). Technology improvements and equipment miniaturisation then allowed the tracking of much smaller animals, including possums and pigeons (e.g. Dennis et al., 2010). Nowadays, research is being undertaken into automated livestock control via virtual fencing (e.g. Swain et al., 2009). This is achieved by employing animal collars that not only utilise GNSS to monitor position but also provide cue (audio) and control (mild electric shock) stimuli to deter animals from entering an exclusion zone (Figure 2).

Drop bears

The drop bear (*Thylarctos plummetus*) is a tree-dwelling, predatory marsupial that closely resembles the koala and is therefore hard to spot. Colloquially, it is often referred to as the carnivorous 'evil twin' of the koala because it is a vicious creature sharing a very similar habitat. The drop bear is a strongly built animal with powerful forearms and claws for climbing and holding on to prey. In stark contrast to the smaller koala, it has large canine teeth that are used very effectively as biting tools.

The drop bear generally hunts during the day by ambushing ground-dwelling animals from above, skilfully latching onto the victim's neck to kill its prey. Quietly waiting in a tree for several hours, it closely resembles a sleeping koala. Once prey is within striking range, the drop bear will plummet several metres out of the tree to pounce on top of the unsuspecting victim (Figure 3). The initial impact generally stuns the prey, allowing it to be bitten on the neck and quickly subdued. Medium to large mammals make up most of the animal's diet (Hosking, 2013), and often the prey is considerably larger than the drop bear itself. A nocturnal variation of the species (*Thylarctos plummetus vampirus*) has resorted to draining the prey of its blood rather than feasting on its flesh (Lestat, 2010).

The distribution of drop bears across Australia is quantified by the National Drop Bear Index (NDBI), which indicates the average population density per square kilometre. As illustrated in Figure 4, the drop bear is mainly found in coastal regions of eastern and southern Australia, stretching from the Cape York Peninsula to Tasmania. Populations also extend for considerable distances inland in regions with enough moisture to support suitable woodland not limited to eucalypts. Woodland is crucial since drop bears are not easily able to drop from spinifex bushes and desert plants. Furthermore, fewer victims in more arid environments reduce the ability to work downwards through the food chain and thus considerably lower survival rates. Reports of periodic attacks on opal miners in Coober Pedy are questionable and may be related to excessive consumption of cooling amber fluids in dry areas. Aboriginal dreamtime legends suggest that the drop bear was once much more widespread, hence the need for contemporary conservation.

Unlike other peculiar Australian animals such as the bunyip and hoop snake, which are rarely encountered in even thinly populated areas, the drop bear poses a considerable risk to unsuspecting bushwalkers (particularly tourists) because it looks very similar to the koala. While the Australian government has been accused of orchestrating a conspiracy to cover up the existence of drop bears in order to protect the tourist industry (Langly et al., 1999), these claims have never been substantiated.

Protection from drop bear attacks

Drop bears do not specifically target human beings. Yet there have been several cases where humans have fallen victim to drop bear attacks, resulting in serious lacerations and even death (Home and Away, 2011). Numerous disappearances may also be attributed to drop bear activity (e.g. Holt, 1967; Hussey, 1989; Mulder and Scully, 2000). Over the years, several methods have been suggested to protect humans from drop bear attacks, although their effectiveness often remains scientifically inconclusive (e.g. Janssen,

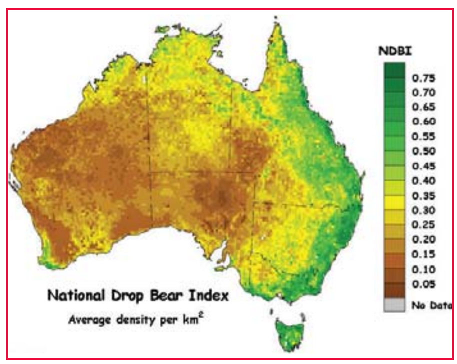


Figure 4: Distribution of drop bears in Australia, quantified by the National Drop Bear Index (NDBI).

2011). These methods include wearing forks in the hair, spreading Vegemite or toothpaste behind the ears or under the armpits, urinating on oneself, and avoiding talking in a foreign language or an accent other than Australian.

There is unmistakable evidence that tourists are much more likely to be attacked by drop bears than Australians. Genetic analyses suggest that this may be related to the Australian ‘mateship’ trait, which extends to animals unique to Australia (Crikey and Beauty, 2008). Furthermore, drop bears can detect foreign languages and are prone to target the origin of such sounds, while using the Aussie lingo may fool the average drop bear (Stewart, 2005). It has also been shown that by-products of the interaction between chemicals found in Vegemite and those found in human sweat repel drop bears (Honeydew, 2003). Most Australians and immigrants who have lived in Australia for long periods of time tend to eat Vegemite on a daily basis. Therefore they exude these chemicals through their skin permanently and are thus protected. Visitors, on the other hand, do not have this ‘natural’ protection and are therefore advised to apply a liberal amount of Vegemite to the skin. The most suitable area is just behind and towards the top of the ear because this area is prone to sweating and closest to the top of the head.

However, drop bear attacks on humans are rare. This is mainly because Australians are familiar with drop bear ecology, tourists are deliberately diverted, and reality TV survivor series are usually undertaken elsewhere. Extensive studies have revealed that the best protection against attacks is to wear a motorcycle helmet when bushwalking in drop bear territory, although this may be impractical in tropical regions (Skywalker, 2008). An accomplished method of determining whether a drop bear may be lurking in the flora canopy is to lie down beneath a tree and spit upwards. If a drop bear is sleeping above, it will most likely wake up and spit back (Young et al., 1981). It should be noted, however, that this approach includes some risk. The consequences can be devastating if drop bears are on the hunt for prey or in the middle of the mating season.

Indirect GNSS-based tracking of drop bears

Monitoring drop bears is essential to ensure that a sustainable animal population is maintained, while limiting the possibility of attacks on humans. Conventional GNSS-based animal tracking methods require the sensor to be directly attached to the animal of interest. This makes studying tree-dwelling species like the drop bear extremely difficult because the tree canopy regularly causes extended periods of complete GNSS signal loss. Due to the viciousness of the drop bear (even under sedation), there is a considerable risk of injury when the sensor is attached. The GNSS sensor is also prone to severe damage and loss during attacks on prey. The animal’s habit of rubbing its body against tree branches further limits sensor life. This severely reduces the availability of meaningful tracking data and substantially increases the cost of drop bear tracking.

These drawbacks can be avoided by employing an indirect GNSS-based approach, which involves tracking the prey rather than the predator (Janssen, 2012). The animal population in a particular area is then mapped by pinpointing the location and timing of drop bear attacks. Drop bears are known to be very territorial. They do not stray far from a relatively small number of trees in close proximity that are used as hunting ground. The location of attacks therefore provides a good indication of where a drop bear resides.

Case study

To prove this theory, a case study was undertaken in the northern part of Morton National Park, located about 120 km southwest of Sydney. The indirect GNSS-based tracking approach was used to estimate the number of drop bears inhabiting this area. Several research assistants (mainly thrill-seeking international students in dire need of financial support) were equipped with GNSS sensors to track their position during bushwalks off the beaten track.

The differential GNSS positioning technique was employed to obtain high-quality real-time positioning solutions relative to a Continuously Operating Reference Station (CORS) nearby. All data gatherers were wearing heavy-duty bike helmets and neck protectors to guard against potential injuries. The field work took place on seven consecutive days starting on 1 April 2012. At times, dense tree cover caused some tracking problems and subsequent data gaps. However, coordinate solutions were generally accurate at the decimetre level or better.

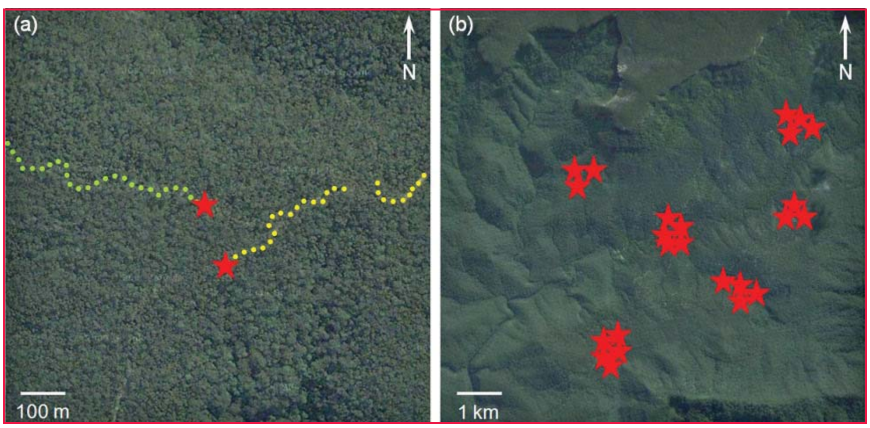
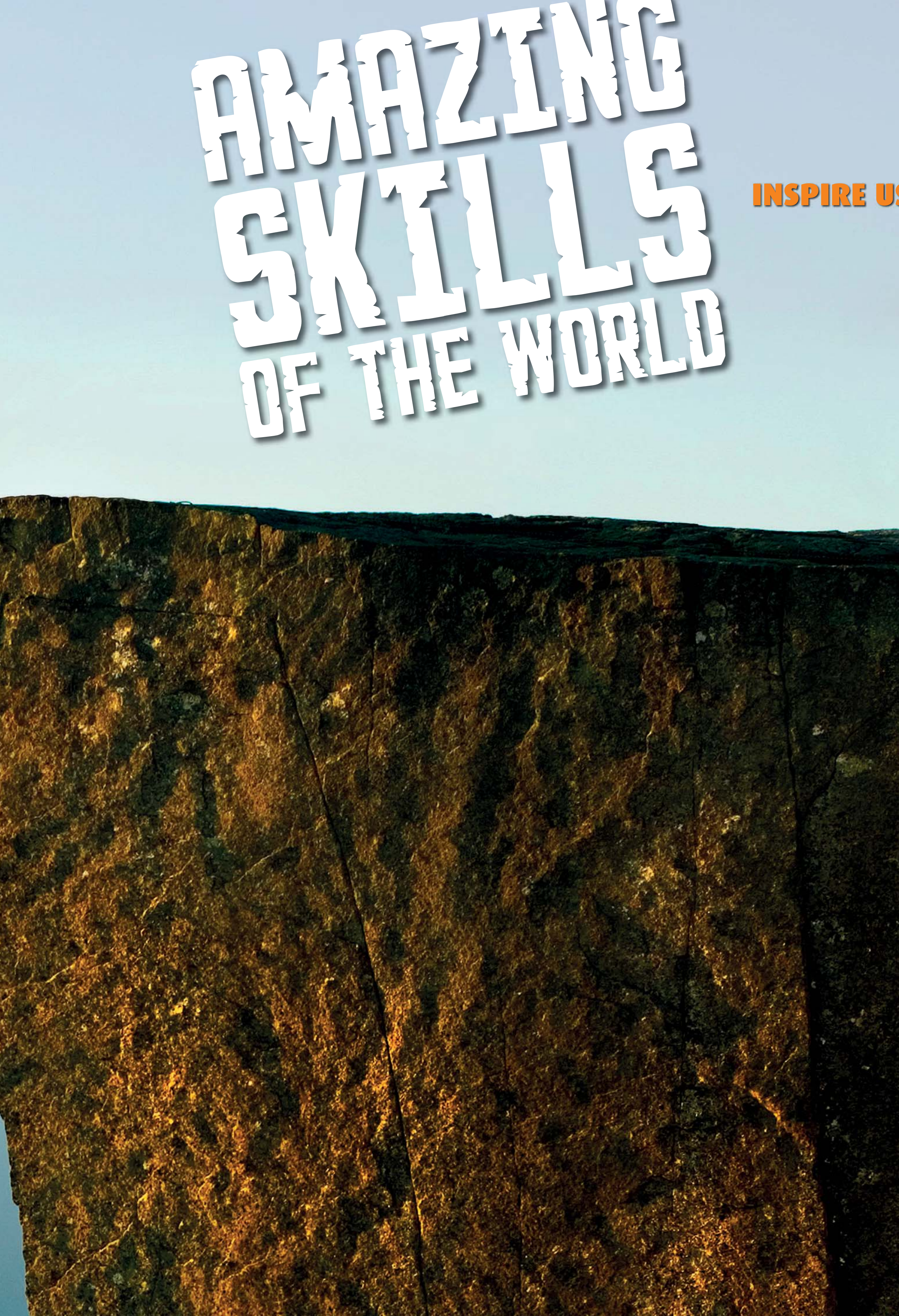


Figure 5: (a) Example of two GNSS trajectories ending with a drop bear attack (denoted by a star), and (b) summary of all drop bear attacks observed.

Photo: Sindre Lundvold

NORWEGIAN EXTREME ARTIST, ESKIL RONNINGSBAKKEN, DURING A BALANCING ACT AT PULPIT ROCK, 1982 FEET ABOVE THE LYSEFJORD, NORWAY, 2006.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Location and size of the population

The GNSS trajectories of the bushwalkers were used to determine the location (and timing) of drop bear attacks. Figure 5a shows an example of two typical tracks culminating in an attack, while Figure 5b shows a map illustrating the spatial distribution of all drop bear attacks observed. It is evident that the attacks appear in distinct clusters, indicating that six drop bears were involved. This leads to the conclusion that at least six drop bears inhabit the study area. The timing of the attacks (data not shown) supports this result.

An examination of kill sites and animal droppings in the study area was conducted a month before and after the GNSS field work was undertaken. This provided an independent method of estimating the number of resident drop bears and confirmed the findings obtained using the indirect GNSS-based animal tracking approach.

Hunting behaviour

In an additional investigation, pairs of data gatherers bushwalked along the same path to examine whether foreigners were more prone to drop bear attacks than locals. In the first scenario, an Australian was followed at a distance of about 50-100 metres by an international research assistant. In the second scenario, the two data gatherers would swap positions. While the relatively small data sample collected precluded a rigorous scientific analysis, some general comments can be made.

In both scenarios, Australians were far less successful in being 'dropped on' than foreigners. Only 10% of Australians were targeted in the event of a drop bear attack. It was later discovered that those Australians were not fond of Vegemite, lending further weight to Honeydew's (2003) incisive study. The results further indicate that drop bears do not necessarily target the last person walking in a line. However, more research into the behaviour of drop bears is required to confirm these findings, which may reflect seasonality and the presence of alternative food sources.

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It should be noted that no animals were harmed during this case study. Likewise, none of the bushwalkers were injured, with the exception of occasional bruising and a few minor lacerations that were graciously endured in the name of science.

Conclusion

This paper has presented an indirect approach for tracking drop bears using GNSS technology. Tracking the prey rather than the predator has proven to be effective in determining the number and spatial distribution of drop bears present in the study area. It has also revealed the animal's particular nutritional targeting preferences. This bush-path breaking study has begun to provide a much better understanding of the ecology of the drop bear. Bushwalkers should be vigilant when hiking along less frequented paths in Australia and take precautions in areas known to be inhabited by drop bears. In these areas, conservation practices can now be enhanced.

While GNSS positioning quality was generally at a sufficiently high level, occasional data gaps were encountered due to dense tree canopy (cf. Figure 5a). Following the deployment of additional satellite constellations currently under development (e.g. Europe's Galileo, China's Beidou and the Indian Regional Navigation Satellite System – IRNSS), a much larger number of GNSS satellites and frequencies will be available in the near future. This is expected to significantly enhance tracking performance, particularly in Australia which will be a 'hotspot' for global and regional navigation satellite systems. Additional benefits could be gained by combining the GNSS sensor with an Inertial Navigation System (INS) to bridge anticipated periods of GNSS signal loss in the forest.

It should be noted that this study was conducted entirely outside normal working hours and not funded by the taxpayer in any way, shape or form. All views expressed in this paper are those of the author and do not necessarily reflect the views of his employer. Prof. John Connell of the University of Sydney is gratefully acknowledged for providing invaluable comments and suggestions during the preparation of this paper.

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